Objectives of ACE SWG Workshop

2013 & 2014 ACE Pre-formulation Activity

HQ Guidance & Feedback

Workshop Objectives

ACE Mission Science

ACE is a aerosol-cloud and ocean ecosystem mission

"… to reduce the uncertainty in climate forcing in aerosol-cloud interactions and ocean ecosystem CO2 uptake" - Decadal Survey pg 4-4

Aerosol-cloud component science objectives are:

1. reduce the uncertainty in aerosol forcing as a component in climate change
2. quantify the role of aerosols in cloud formation, alteration of cloud properties and changes in precipitation.

Ocean ecosystem goals are to:

1. characterize and quantify changes in the ocean biosphere
2. quantify the amount of dissolved organic matter, carbon, and other biogeochemical species to define the role of the oceans in the carbon cycle (e.g., uptake and storage).

The ocean ecosystem imager needs aerosol measurements to optimize their retrievals which is an important reason for the combined payloads.

ACE Mission Implementation and Challenges

ACE Payload currently considers the following candidate instruments:

1. Lidar for assessing aerosol/cloud heights and aerosol properties.
2. Multi-frequency Doppler cloud radar for cloud properties and precipitation
3. Multi-angle, wide-swath polarimeter for imaging aerosol and clouds
4. Multi-channel wide-swath spectrometer for ocean ecosystems (OES)

5. IR wide-swath imager for cloud temperatures and heights
6. High frequency wide-swath radiometer for cloud ice measurements
7. Low frequency wide-swath radiometer for precipitation measurements

It is anticipated that all instruments will be openly competed.
The payload may require more than one spacecraft.

Instruments in gray were mentioned in the NAS DS ACE description. The Science Working Group considers these instruments/measurements critical to the mission.

ACE Mission Issues

There exists a lack of definitive guidance as regards constraints on:

- Mission budget
- Sensor complement
- Connection, or not, to PACE
- Launch readiness date (schedule)
- Connection, or not, to other missions (e.g., GPM)
- Formation flying with other satellites

This has made it difficult to solidify our plans.

Technical Progress in FY2013 (1 of 3)

- Technology Readiness Assessments completed for 7 aerosol and cloud Instrument Concepts (3 polarimeters, 3 radars, lidar)
- Technology Maturation Plans developed for 6 Instrument Concepts
- Advanced the TRL of 6 instrument concepts, including:
  - AirMSPI-2 in development (extends AirMSPI UV/VNIR design into SWIR), test fly in Spring/Summer 2014
  - Designed and building SWIR sensor head for PACS
  - HSRL-2 (full 3b+2a) flew on LaRC King Air in DISCOVER-AQ/PODEX in Jan/Feb 2013 and in DISCOVER-AQ in Sept 2013
  - Demonstrated ACE-like data production using prototype algorithms
  - Two alternate Dual-Frequency Subscale Radar Antenna nearly complete, one to test fly in Summer 2014, the other is fabricated, delivered and will be lab tested during winter 2013
- Conducted UV Laser Lifetime Study (ongoing) to reduce laser risk

Technical Progress in FY2013 (2 of 3)

- Successful PODEX deployment in Jan-Feb 2013 for critical data acquisition to support algorithm development and trade studies for aerosols and clouds with AirMSPI, RSP & PACS, on NASA ER-2; and HSRL-2 on D-AQ NASA King Air
- AirMSPI and RSP successfully flew in SEAC^{4}RS
- HSRL-1 successfully flew ocean ecosystem mission coordinated with AMT-22 oceanic research cruise
- HSRL-2 successfully flew on DISCOVER-AQ in January-February 2013 (California) and September (Houston) on the King Air
- Initiated planning for RADEX, joint with IPHEX and OLYMPEX (GPM) in 2014 & 2015/16
- Two ISS Experiment/Instrument Concepts developed and submitted
  - PACS derivative
  - PreSTIDigiRadar (joint between JPL-GSFC) to advance TRL of ***all*** ACE radar concepts

Technical Progress in FY2013 (3 of 3)

- Advanced Algorithm Development – aerosol and cloud ACE priority in FY13
  - AirMSPI retrievals of fractional optical thickness demonstrated using JPL vector Markov Chain RT code. Robust retrievals of cloud drop size also demonstrated with AirMSPI PODEX and SEAC^{4}RS data
  - RSP algorithms matured for clear sky and cloud, but calculation speed remains issue
  - PACS algorithm moving to GRASP (next generation algorithm approach) with Oleg Dubovik (University of Lille) as lead

  - ACE Lidar simulation tools enable trade studies concerning science vs. complexity cost:
    - GSFC tool completed and performance confirmed (uses GEOS-5)
    - LaRC tool upgraded to include both ocean and atmospheric simulation
    - JPL tool (Tanelli AIST) incorporates multiple ACE instruments employing consistent aerosol/cloud microphysical description for all instruments

  - HSRL-2 retrieval systems demonstrated during PODEX and DISCOVER-AQ; further enhancements are underway regarding quality and additional parameters

  - Initiated joint HSRL-polarimeter algorithm development for aerosols

  - Initiated multi-sensor algorithm development for clouds
    (2-freq Doppler radar + microwave + submm + ir + lidar + polarimeter)

  - Completed analysis of the benefits of using radar polarization diversity pulse pair approach, and accounted for 3D effects using simulator to improve Doppler accuracy; both may lead to reduction in antenna size/cost

Key Science Accomplishments for 2013

(1 of 2)

- *PODEX data acquisition was highly successful; close coordination with D-AQ added major value toward achieving aerosol and cloud PODEX goals*
- *Proceeding toward RADEX, specifically, a collaboration with GPM GV planned IPHEx (Spring 2014) and OLYMPEX (winter 2015/16) => demonstrate capability of ACE-like multi-sensor cloud retrievals for precipitating shallow and deep cloud systems and wide range of cloud types*
- *Implemented spectral-bin microphysics and radar simulator in JPL LES model*
- *Investigators looking at 3D effects in PODEX polarimeter data – important to quantify*
- *Held productive workshop (July 2013), and continuing telecons, examining the potential synergy between aerosol and cloud ACE concept and science drivers for next generation of global precipitation measurements = input to next Decadal survey (CAPMM)*

Key Science Accomplishments for 2013 (2 of 2)

- *Conducted first-ever field measurements with an ocean-profiling HSRL*
  - *HSRL-1 deployed on NASA P3-B near Azores in October 2012, with 1-m vertical sampling, and Research Scanning Polarimeter measurements*
  - *Overflew Carbon Project oceanographic cruise (AMT22 with RRS James Cook) providing in-situ optical data to validate lidar ocean retrievals, sometimes in conjunction with CALIOP overflights*
  - *Objective: demonstrate unambiguous retrievals of diffuse attenuation (Kd) and phytoplankton backscattering (bbp) that will reduce large uncertainty in estimates of net primary productivity, Retrievals will be validated over the next year.*
  - *Preliminary matchups indicate good agreements between satellite, airborne and ship measurements of ocean particle scattering coefficients*
- *Published (GRL) first global analysis of ocean particulate organic carbon and phytoplankton carbon from a space-based lidar (CALIPSO) –"Space-based LIDAR measurements of global ocean carbon stocks", Michael J. Behrenfeld, Yongxiang Hu, Chris A. Hostetler, Giorgio Dall'Olmo, Sharon D. Rodier, John W. Hair, Charles R. Trepte*
- *Validation of satelite-derived fluorescence-based quantities - Collected daily radiometric and biogeochemical measurements along 46 day (10,000 km) AMT22 cruise and consolidated all pre-existing fluorescence field data in NASA databases. Analysis in FY14.*
- *Global CDOM Algorithm - Hooker et al (2013) created and validated a colored dissolved organic matter (CDOM) algorithm applicable to coastal and near-shore waters, and extended it via data from Antarctic and Arctic. Comparison to new data collections from North Pacific and ACE shallow-water campaigns indicate a robust algorithm.*

ACE Objectives for FY2014/FY2015 (1 of 2)

- **Science**
  - *Continue pushing algorithm development and analysis*
    - Special emphasis on moving forward with multi-sensor approaches
    - Pay attention to algorithm speed and implementability
  - *Analyze and intercompare PODEX data (L1 => L2)*
  - *Acquire needed cloud data - RADEX*
    - Plan and execute in cooperation with IPHEX (GPM) in Spring 2014
    - Plan jointly with OLYMPEX (GPM) in Winter 2015-16
    - Explore potential of multi-frequency radar and microwave cloud algorithms
  - *Take advantage of opportunities for further data acquisitions and analysis, e.g.,*
    - SEAC4RS (ER-2: AirMSPI & RSP with CPL etc)
    - HYSPiri campaign (ER-2: AirMSPI)
    - SABOR (B-200: HSRL-1 & RSP)

ACE Objectives for FY2014/FY2015 (2 of 2)

Technology Maturation Goals

- *Ocean Ecosystem Spectrometer*
- *Lidar*
  - HSRL (LaRC) from TRL = 5 to 6
- *Polarimeters*
  - MSPI (JPL) from TRL = 4 to 6
  - PACS (UMBC/GSFC) from TRL = 4/6 to 6
  - APS (GISS) at TRL = 6
- *Radars*
  - ACERAD (JPL) from TRL = 4 to 6
  - ACE Radar (GSFC/NGES) from TRL = 4 to 6
    - ACE Radar Options (GSFC/NGES) antenna and solid state power
  - C2D2 (JPL) from TRL = 3 to 6

Issues and Challenges Posed to HQ

- Mission Architecture
  - *Number of spacecraft (assuming 2)*
  - *Orbit altitude (assuming ~450 km)*
  - *EarthCARE at ~400 km vs A-Train at 715 km vs JPSS at 824 k*
  - *Connection to PACE, constellation flying,…?*
  - *Connection to GPM Next,…?*
- Programmatic Concerns
  - *Prospective partners?; Possibility of Formation with Research and/or Operational satellites strongly dependent on resolution of Orbit Altitude*
  - *LRD? or wait for next Decadal Survey?*
- Tech Maturation
  - *Scope of tech maturation*
  - *Available resources; short and long term*
  - *Initiate Instrument Teams for Radiometers (IR, Submm, Microwave)*
  - *Initiate Working Group on Polarimeter algorithm development approach*
  - *Ocean Ecosystem Spectrometer maturation needs to be addressed since the PACE mission is in an unfunded holding pattern*

HQ Guidance to ACE, January 2014

Continue to concentrate on instrument capabilities, science sensitivity to measurement capabilities, and associated algorithm development challenges.

- Complete STMs for science thrust areas,
- Complete UV Laser lifetime study, and publish it,
- Work with PACE Team to explore options for how PACE and ACE ocean color instrument requirements may best be defined in coordinated way,
- Complete processing and analysis of PODEX campaign data,
- Develop rationale showing how future ACE airborne campaigns support ACE requirements in light of upcoming Decadal Survey,
- Support ESM SEWG studies on TRL definition and instrument cost studies,
- Complete a comprehensive development report on ACE mission study activities (last 5 years of pre-formulation work),
- Hold an ACE SWG Workshop.

No need for

- additional mission concept developments
- refinements to mission level 1 science requirements,
- updates to estimates of full mission costs.

HQ Feedback to ACE, November 2014

Cost: NASA will not support Flagship class missions => minimize, but no limits specified.

- Find partnerships to reduce costs, e.g., formation fly with suitable operational (EPS-SG or JPSS) or research missions

=> major implications for orbital altitude (EPS-SG at 817 km, JPSS at 824 km)

- Possible leverage EV-I ?? or EV-M
- Seek international partners to contribute instruments and/or launch

Do not expect HQ to tell us what to do.

Schedule: No MCR in near future, probably not till after next Earth Science Decadal is released, nominally in early 2017 => MCR in late 2017 at earliest. => Launch in 2025, with aggressive schedule (MCR + 7-8 years allowing for AO as instr procurement mechanism.

Resources for Technology Maturation: ESTO is the funding mechanism, i.e., ACT and IIP. Also possible via EV-I, or EV-M (ISS).

Near Term: Focus on the big 3 (Polarimeter, Lidar, Radar) and rely on PACE for OES, otherwise see (1), (2) and (3).

Question posed: How important to the science is the current ACE partnerships between:

Aerosols and Ocean Ecosystems,

Aerosols and Clouds.

i.e., how mission critical to achieve our science objectives?

ACE SWG Workshop Objectives

1. Revisit/update of the ACE science traceability matrices.

2. Report on Technical Readiness of the lidar, radar, polarimeter, and OES

3. Consider orbital scenarios, sensitivity-science trades, international collaborations and their advantages/challenges. i.e., reduce mission costs appreciably but maintain the science.

4. Clarify the PACE-ACE connection.

5. Plan ACE white paper for the next ES Decadal Survey.
   Charge to NRC expected in early Fall?.